July 30, 2009

Review of U.S. Human Space Flight Plans Committee
NASA Headquarters
300 E St SW
Washington DC 20024-3210

Dear Committee Members:

Thank you for the opportunity to comment on NASA's objectives in human space flight. I respect the viewpoint of those who argue that NASA's priorities for the foreseeable future should be high scientific value unmanned exploratory probes, with a focus on "Mission to Planet Earth," because of the tremendous cost of manned space flight. However, I agree strongly with visionaries such as von Braun, Heinlein, and Hawking who insisted that we must build a "bridge to the stars" (in von Braun's words) and that outer space must ultimately become a place of human habitation and not merely a subject of scientific exploration (as essential as that is). Regardless of whether we place greater emphasis on manned or unmanned exploration in the near future, however, the urgent issue is to become "space capable"---and given this fact, it is almost painfully obvious that the real barrier to genuinely sustainable space capability is the fact that virtually all methods of propulsion we presently have are chemical. This is one of the main reasons, if not the main reason, that humanity does not already have extensive bases on the Moon and Mars, and manned exploratory probes to the farthest reaches of the Solar System.

As a germane illustration of the difference that propulsion can make, a simple order-of-magnitude calculation shows that a spacecraft that was capable of maintaining 1 g acceleration continuously could get from Earth to Mars in roughly one week---instead of the months that would be required if all that can be done is boost the craft to Earth's escape velocity and then drift in freefall most of the way. Such a 1 g spacecraft would boost toward the target until the halfway point, turn around, and decelerate the rest of the way. However, no chemically-fueled rocket could possibly hope to deliver such performance. The LOX/LiH main engines of the Space Shuttle, for instance, are close to the most powerful chemical rockets that are theoretically possible, and yet they barely have enough kick, even with the assistance of massive SRBs, to put the craft and a useful payload into low Earth orbit. The spacecraft can only return to Earth by literally crashing into the upper atmosphere at orbital speeds, and this tends to be dangerous (as we learned sadly) and very expensive. Imagine how much cheaper (not to mention safer) space travel would be if astronauts has enough “delta-v” to carry out a powered deceleration before re-entering Earth’s atmosphere.

As another illustration of the importance of the problem of propulsion, consider the challenge of deflecting dangerous NEOs, which has rightly received much attention, and which members of the Planetary Society recently identified as having a very high priority. If Earth is threatened by an NEO, we need to be able to get out to it quickly and then have the power to deflect the object effectively and immediately. Whether or not this is to be done by a manned mission or by unmanned spacecraft is beside the point; the real problem is that the energy requirements will be high. It is currently presumed that with chemically fueled rockets carrying nuclear warheads we could probably deflect large impactors so long as we had many months advance notice, but that is at the outer limits of our theoretical capabilities even if it is possible at all. A truly effective system that could detect virtually any object that could pose a threat to humanity and deflect or destroy it on relatively short notice would require far more powerful means of propulsion than we currently have.

I would therefore like to urge that whatever detailed objectives for space flight may be defined, manned or otherwise, NASA makes it one of its highest priorities to support and encourage research and development into propulsion systems that will eliminate the current dependency of space flight on chemically fueled rockets. This should include some support for research into very advanced “blue sky” propulsion methods that are within the realm of remote theoretical possibility, such as warp drives or direct control of gravitation. However, if we want to be able to put people on Mars within weeks rather than months or years at a cost that is compatible with other national objectives, and if we want to be able to carry out other space-based tasks such as detecting and deflecting NEOs with near-100% effectiveness, and if we want to be able to do such things within the next decade or two, spaceflight has to go nuclear.

In the 1960s solid-core nuclear fission powered rockets were developed that were within sight of operational capability, but they were abandoned because they did not offer all that much improvement in specific impulse over the best chemical rockets and carried the risk, however slight, of catastrophic nuclear accident. More efficient gaseous-core fission rockets are theoretically possible but would require a great deal of development and would still likely be risky. Despite this, next-generation fission-based nuclear rockets are likely going to be the first forms of nuclear propulsion that we will be able to use for interplanetary missions. Probably it is most realistic to suppose that an intermediate technology could be developed first, in which conventional chemical boosters allow the assembly of a large spacecraft in orbit, and then a fission-powered nuclear system accelerates the spacecraft to its destination. A hybrid system like this is certainly within the reach of current scientific and technical capabilities, although it would still be quite expensive and would still involve some risk since the fission fuel would have to be ferried to orbit. As much as I personally would like to see boot prints on Mars, it seems to me that there is little point in planning a chemically-fueled Mars mission to occur (say) ten or fifteen years from now when it ought to be possible to develop a hybrid chemical-nuclear interplanetary propulsion system such as I describe, or possibly something even more effective, in about the same amount of time. A chemically-fuelled mission to Mars would be not much more than a nostalgic reprise of the magnificent gesture of the Apollo program and it would have as little future; a nuclear-propelled mission to Mars would open the door to human exploration and habitation of the Solar System.

What NASA really needs, however, is to actively promote the development of controlled nuclear fusion. The late Dr. Robert Bussard, a pioneer of nuclear rocketry, argued that it would be possible within the next few years to have fusion powered generators and rockets based on non-equilibrium plasma physics, and it is likely enough that he was right about this that the possibility deserves large and immediate support. Currently the US Navy is funding (at a very modest level) research into one such possible approach, the so-called polywell. Whether or not Bussard's polywell can be made to work, every reasonably possible approach to controlled fusion needs to be explored, with a real sense of urgency, and with enough funding to actually bring a variety of concepts to test as soon as possible.

The benefits of controlled fusion power have often been explained, but they are worth repeating: virtually unlimited fuel supply, minimal radiation risk (almost none if aneutronic reactions are used), zero emissions of greenhouse gasses and other chemical pollutants when used in the atmosphere, and the theoretical potential for a combination of high thrust and high specific impulse that could make it feasible to carry out cost-effective space operations anywhere in the Solar System.

President Obama recently stated that "no single issue is as fundamental to our future as energy." Nowhere is this more apparent than in space travel. Just as modern industrial society can no longer depend on fossil fuels if it hopes to have a future, space travel can no longer depend on chemical fuels if it hopes to fulfill its promise. Clearly, as well, if NASA successfully promoted the development of advanced fission and fusion power for space propulsion, the technology that flowed out of this effort could go a long way toward eliminating worries about climate change and the dependency on dwindling fossil fuel supplies. The barrier to true space capability is propulsion, and the barrier to more effective means of propulsion than we have now is energy---and that is precisely the problem that everyone in the world has today anyway.

I recommend that NASA make it one of its highest priorities to fund, advocate, promote, and facilitate the development of advanced propulsion systems, especially those based on nuclear fusion.

Please feel free to reproduce these comments publicly if you wish to do so.

Yours sincerely,

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